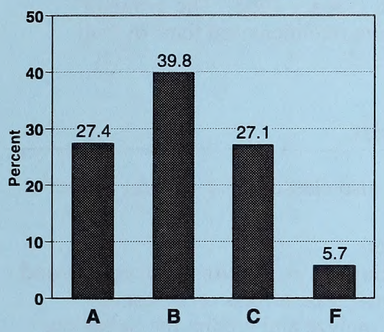
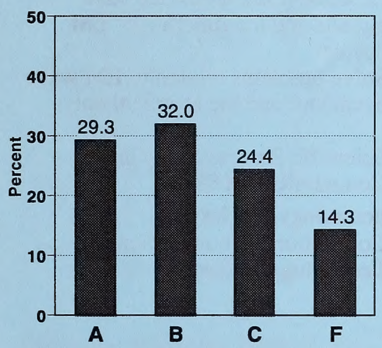
Physics 30

Diploma Examination Results
Examiners' Report for January 1998

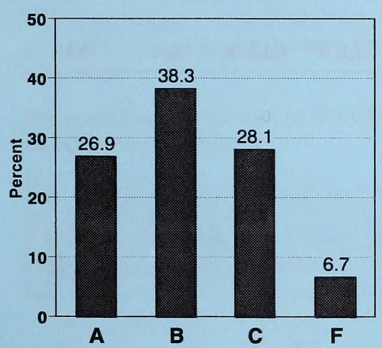
School-Awarded Mark



Diploma Examination Mark



Final Course Mark



The summary information in this report provides teachers, school administrators, and students with an overview of results from the January 1998 administration of the Physics 30 Diploma Examination. This information is most helpful when used with the detailed school and jurisdiction reports that have been provided electronically to schools and school jurisdiction offices. A provincial report containing a detailed analysis of the combined January, April, June, and August results is published each year.

Description of the Examination

The Physics 30 Diploma Examination consists of 37 multiple-choice questions worth 52.9%, 12 numerical-response questions worth 17.1%, and two written-response questions worth 30% of the total examination.

Achievement of Standards

The information reported is based on the final course marks achieved by 3 268 students in Alberta who wrote the January 1998 examination.

- 93.3% of the 3 268 students achieved the acceptable standard (a final course mark of 50% or higher).
- 26.9% of students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 36.0% of the students who wrote the January 1998 examination were female.

- 95.8% of the female students achieved the acceptable standard (a final course mark of 50% or higher).
- 29.0% of the female students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 64.0% of the students who wrote the January 1998 examination were male.

- 91.8% of the male students achieved the acceptable standard (a final course mark of 50% or higher).
- 25.8% of the male students achieved the standard of excellence (a final course mark of 80% or higher).

Students are demonstrating increased skills in dealing with questions related to the Science, Technology, and Society strand of the curriculum. However, students continue to have difficulty with conservation laws and problems involving multiple steps. This may be a result of students relying on algebraically derived formulas that they have memorized rather than basing their solutions on basic physics principles.

Students First!
Student Evaluation

Alberta
EDUCATION

Provincial Averages

- The average school-awarded mark was 70.1%.
- The average diploma examination mark was 68.2%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 69.6%.

Approximately 6.6% of the students who wrote the examination in January 1998 and received a school-awarded mark had previously written at least one other Physics 30 Diploma Examination during the January 1997 to January 1998 period. This sub-population (216) achieved an examination average of 65.2%, compared with 68.5% for the population (3 052) who first wrote a Physics 30 examination in January 1998. The group of students who rewrote increased their overall average by 17.3%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students achieving the acceptable standard will obtain a mark of 50% or higher, and students achieving the standard of excellence will obtain a mark of 80% or higher.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer. For multiple-choice and numerical-response questions, the "Difficulty" indicates the proportion (out of 1) of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score achieved by students who wrote the examination.

Questions are also classified by general learner expectations.

Knowledge:

- GLE 1 Explain gravitational, electrical, and magnetic effects on systems
- GLE 2 Analyze and predict the behaviour and physical interactions of objects
- GLE 3 Describe and analyze resistive circuits and the function of EM devices
- GLE 4 Solve problems related to EM wave behaviour and the atomic theory

Skills:

- SPC Scientific Process Skills and Communication Skills

Science, Technology, Society:

- STS Connections Among Science, Technology, & Society

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPC	STS
MC1	B	0.656		✓				
MC2	D	0.647		✓				
MC3	C	0.765		✓				
NR1	1.04	0.808		✓				✓
MC4	A	0.850		✓				
NR2	1.63	0.725		✓				
MC5	D	0.503	✓				✓	
MC6	B	0.957	✓				✓	
MC7	C	0.850	✓				✓	
MC8	A	0.858		✓				
MC9	D*	0.506				✓		
NR3	5.67	0.630				✓		
MC10	A	0.753				✓		✓
MC11	C	0.896			✓			✓
MC12	C	0.821			✓			✓
NR4	9.09	0.789			✓			✓
NR5	1.24	0.879			✓			

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPC	STS
MC13	A	0.579			✓			✓
MC14	D	0.625			✓			
MC15	B	0.987		✓				
MC16	D	0.882		✓				
MC17	B	0.543				✓	✓	✓
MC18	D	0.337	✓					
MC19	B	0.661			✓			✓
MC20	D	0.346			✓		✓	
MC21	B	0.843			✓			
MC22	A	0.625	✓				✓	
MC23	C	0.836	✓				✓	
MC24	C	0.759				✓	✓	
MC25	B	0.823	✓				✓	
MC26	D	0.699	✓				✓	
MC27	C	0.532	✓				✓	
MC28	C	0.889				✓		
MC29	A	0.736				✓		✓
NR6	8917	0.746			✓			
NR7	2.09	0.740				✓		
NR8	5.5	0.395				✓		
MC30	B	0.667				✓		✓
NR9	2.73	0.796				✓		✓
MC31	A	0.569		✓			✓	
NR10	4.25	0.834				✓		✓
MR11	692	0.707				✓		✓
MC32	A	0.807				✓		
MC33	C	0.474				✓		
MC34	B	0.764	✓					
MC35	B	0.889				✓		
MC36	B	0.527				✓	✓	✓
MC37	A	0.838				✓		
NR12	1.62	0.732				✓		
WR1		0.609		✓			✓	✓
WR2		0.578		✓				✓

*MC9: D if A was selected from MC8; C if B was selected; B if C was selected; and A if D was selected.

Subtests: Machine Scored and Written Response (Average by Subtest)

When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared.

Average Percent Scores of Machine Scored and Written Response

Machine Scored	71.6%
Multiple choice	71.0%
Numerical response	73.6%
Written Response:	60.3%*
Question 1	60.9%
Communication	71.0%
Content	57.3%
Question 2	57.8%

* Individual student scores for Question 1 and Question 2 are each weighted 15% of the total exam.

Average Percent Scores and Total Test Weighting in Percent by General Learner Expectation

		Average	*Weighting*
GLE 1	Explain gravitational, electrical, and magnetic effects on systems	69.2%	14.3%
GLE 2	Analyze and predict the behaviour and physical interactions of objects	65.8%	44.3%
GLE 3	Describe and analyze resistive circuits and the function of EM devices	71.8%	14.3%
GLE 4	Solve problems related to EM wave behaviour and the atomic theory	69.7%	27.1%
Skills	Scientific process and communication skills	64.3%	33.6%
STS	Connections in science, technology, and society	65.1%	50.0%

Multiple-Choice and Numerical-Response Questions

The following table gives results for 4 questions selected from the examination. The table shows the percentage of students in four groups that answered the question correctly. The comments following the table discuss some of the understandings and skills the students may have used to answer these questions.

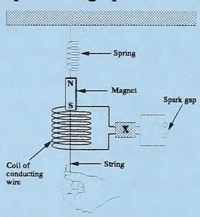
Percentage of Students Correctly Answering Selected Machine-Scored Questions

	Question Number			
Student Group	**MC 20**	**MC 30**	**NR 9**	**MC 31**
All Students	34.6	66.7	79.6	56.9
Students achieving the *standard of excellence* (80% or higher, or A) on the whole examination	55.2	88.3	96.8	84.5
Students achieving the *acceptable standard* (between 50% and 79%, B or C) on the whole examination	28.1	64.0	81.9	50.7
Students who have not achieved the *acceptable standard* (49% or less, or F), on the whole examination	17.9	33.1	35.5	24.6

Use the following information to answer the next question.

Side View of an Electromagnetic Apparatus

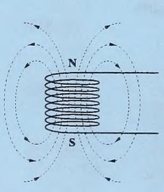
During his studies of electromagnetism, a student proposes the following method of producing sparks.



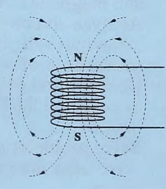
The student pulls down on the string and then releases it, causing the magnet to oscillate. As the magnet moves downward and enters the coil from above, a current is induced in the coil.

20. Which of the following diagrams shows the direction of the magnetic field generated by the induced current in the coil as the magnet moves downward into the top of the coil?

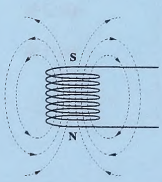
A.



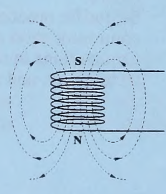
B.



C.



D.



Multiple-choice question 20

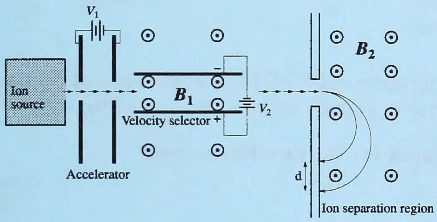
Most students found this question difficult. The fact that more students selected alternative A than the correct response, alternative D, suggests that students do not fully understand the principles underlying Lenz's Law. To successfully answer this question, students needed to understand that in order for energy to be conserved, the direction the induced current flows must be such that the induced field it creates opposes the action of the inducing field. Alternative A shows an induced field that would attract the magnet, thus increasing the total energy of the system. Both machine-scored and written-response field test items confirm that students lack a solid understanding of Lenz's Law.

Use the following information to answer the next question

Carbon Dating Using a Mass Spectrometer

One method of determining the age of archeological remains is carbon dating. Of all carbon isotopes present in living tissue, $1.66 \times 10^{-10}\%$ are carbon-14. The radioactive half-life of carbon-14 is 5.73×10^{3} years. A mass spectrometer is a device that separates ions of different masses and can be used to determine the percentage of carbon-14 present in a sample.

In a mass spectrometer, a source produces gaseous ions that are accelerated by two vertical parallel plates that have a large potential difference between them. The beam of ions enters a velocity selector that allows only those ions with a specific velocity to pass through undeflected. Finally, the ions enter a magnetic field B_2 where the ions are separated according to their mass.



⊙ Indicates B_1 and B_2 directed perpendicularly out of the page.

A leather sandal from an archeological find is analyzed in order to determine the age of the sandal.

30. In the leather sandal, the mass spectrometer measures the carbon-14 content as $8.30 \times 10^{-11}\%$ of all carbon isotopes present. The approximate age of the sandal is

A. 1.43×10^{3} years
B. 5.73×10^{3} years
C. 1.15×10^{4} years
***D.** 2.29×10^{4} years

Numerical Response

9. The carbon atoms in the sandal are ionized by high-energy photons in the source chamber of the mass spectrometer. The ionization energy of carbon is 11.3 eV. The minimum frequency of radiation required in the source, expressed in scientific notation, is $b \times 10^{w}$ Hz. The value of b is __________

(Round and record your answer to three digits.)

Answer: 2.73

Multiple-choice question 30
Most students who achieved the acceptable standard on the examination correctly answered this question. Students were able to use the data provided in the information box and their understanding of radioactive decay to determine that one half-life had elapsed. From this information, they could then correctly calculate the age of the sandal.

Numerical-response question 9
This question clearly distinguished the students achieving the acceptable standard on the examination and those who did not achieve the acceptable standard on the examination. In order to obtain the correct answer, students needed to convert the ionization energy of carbon from electron volts to joules and then use a formula from the data sheet to calculate the frequency of the associated radiation.

To successfully answer this question, students did not need to demonstrate an understanding of ionization energy. However, to calculate the correct answer to numerical-response 8, students needed to recognize that the energy required to ionize an atom is the energy that must be added to the electron to free it from the attractive force of the nucleus.

31. The horizontal speed of the stream of carbon ions through the velocity selector is given by the expression

*A. $\dfrac{|\vec{E}|}{B_1}$

B. $\dfrac{mg}{B_1 q}$

C. $\dfrac{mgd}{q}$

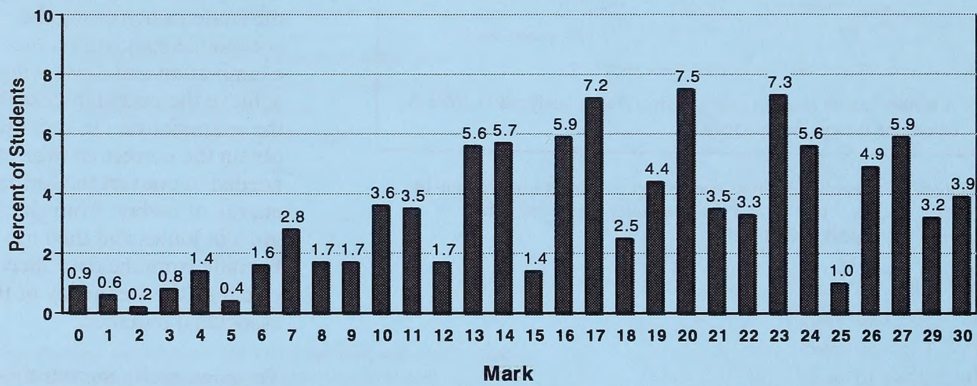
D. $\sqrt{\dfrac{F_e R}{m}}$

Multiple-choice question 31 Students who achieved the standard of excellence on the examination performed very well on this question. They recognized that in order for the ions to pass through the velocity selector undeflected, the net force on them must be zero. By equating the electric and magnetic forces acting on the ions, students were able to solve algebraically for the horizontal speed of the stream of carbon ions. Students not achieving the standard of excellence experience difficulty with this type of question because the solution requires the application of more general principles of physics and does not depend on formulas that can be found directly on the data sheet.

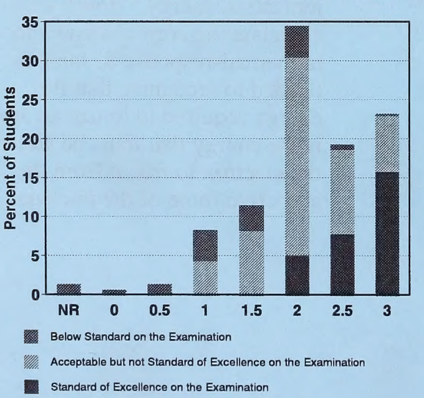
Written-Response Questions

Of all the students who wrote the exam, 67.8% received a mark of 15 or higher out of 30 on the written response. The average mark on the written-response questions was 18.09, or 60.3%.

Distribution of Marks for Written Response

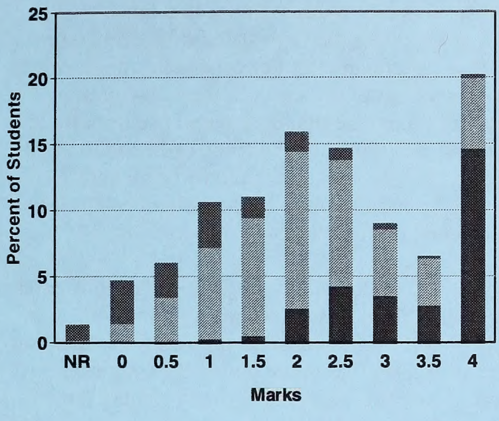


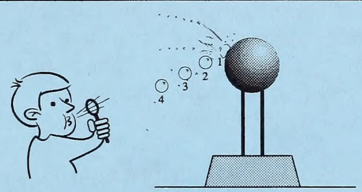
Distribution of Marks for Question 1 - Scale 1



Written-response question 1 was well answered by students. The question had an overall average of 60.9%. To obtain full marks for this question, student responses needed to clearly explain: the initial attraction of the neutral soap bubbles to the generator as a result of induced charge separation; the transfer of electrons from the Van de Graaff generator to the first soap bubble and the transfer of the electrons from the splatters to the remaining bubbles through conduction; that like charges repel and that unlike charges attract as a result of electrostatic forces.

Distribution of Marks for Question 1 - Scale 2





In a classroom demonstration, the dome of a Van de Graaff generator was initially charged negatively. A stream of closely spaced neutral soap bubbles was blown toward the dome of the generator. Much to the surprise of the teacher and the students, the following observations were made:

- the bubbles were initially attracted to the top of the dome of the generator until the first bubble hit the dome
- the first bubble hit the dome and splattered
- all the other bubbles then stopped in mid-air
- the other bubbles were then repelled from the dome of the generator and from each other

Written Response – 15%

1. Using the concepts of electrostatic forces and charge distribution, explain

- why the soap bubbles were initially attracted to the top of the generator
- why, after the first soap bubble splattered, the other bubbles were repelled from the generator and from each other

A diagram or diagrams may help to clearly communicate your ideas.

Note: A maximum of 8 marks will be awarded for the physics used to solve this problem. A maximum of 3 marks will be awarded for the effective communication of your response.

In general, students demonstrated a good understanding of the basic electrostatic forces of attraction and repulsion. Terminology was well used and many students used diagrams effectively to communicate their understanding of induction and charge separation. Students achieving the standard of excellence enhanced their responses by combining their knowledge of electrostatics principles and atomic structure with detailed explanations.

Student responses clearly revealed several areas of misunderstanding. Many students consider "neutral" to be a third type of charge, and following this logic, argued that neutral objects are attracted to negatively charged objects because they are unlike charges. Similarly, they argued neutral objects repel neutral objects because they are like charges.

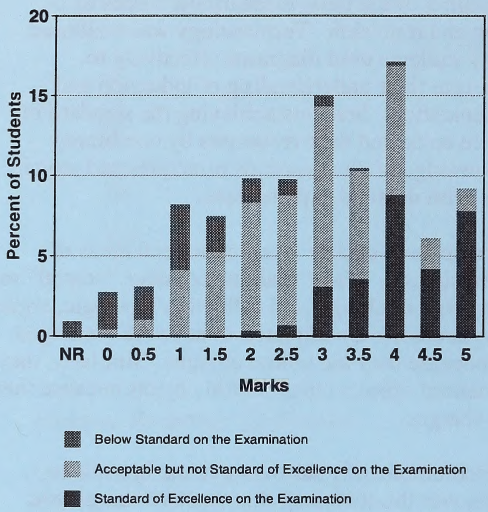
Another common error that was evident in student responses was the statement that positive charge was transferred or moved from one body to another. Many students also indicated that when two bodies come in contact, all of the positive or all of the negative charges move to one of the bodies.

Many students who achieved the acceptable standard but not the standard of excellence answered the question well, but failed to explain why the neutral bubble was attracted to the negatively charged generator, or they started their responses with the assumption that the first bubble was positive. These students demonstrated a good understanding of attraction and repulsion forces and the process of conduction of charge.

Despite the open-ended nature of this question, only 1.5% of students did not attempt the question.

In general, student responses were well organized and students were able to clearly communicate their ideas. In some cases, students knew the laws pertaining to electrostatic forces but they implied them rather than clearly stating them. The average mark for communication was 2.13 out of 3 and the average mark for content was 2.3 out of 4.

Distribution of Marks for Question 2



Written Response – 15%

2. A compact car with a mass of 1.0×10^3 kg is moving at 1.0×10^1 m/s north along a single-lane road. At the same time, a full-size car with a mass of 2.0×10^3 kg is moving at 8.0 m/s south along the same road. The two cars collide head-on. Immediately after the collision, the compact car has a velocity of 4.0 m/s south. The interaction lasted 8.0×10^{-2} s.

- Determine the speed and direction of the full-size car immediately after the collision.
- Show that the collision was **not** elastic.
- Determine the magnitudes and the directions of the average forces of impact on the compact car and on the full-size car.

Clearly communicate your understanding of the physics principles that you are using to solve this question. You may communicate this understanding mathematically, graphically, and/or with written statements.

In **written-response question 2,** the majority of students used conservation of momentum before and after the collision to calculate the final speed of the full-size car. However, a significant number of students neglected to consider the effect of direction in their calculations. Students did recognize that they could use impulse to calculate the magnitude of the force of impact on both cars. Most students calculated the force on each car independently and did not refer to Newton's Third Law or action–reaction pairs in their solution.

A few students approached this question using impulse and Newton's Third Law as a starting point. To calculate the change in velocity, they used the fact that the force of impact was equal and in the opposite direction. From this value, they then calculated the final velocity of the full-size car.

Students had a considerable amount of difficulty dealing with direction consistently in their solutions for velocity and force. Many final answers were incorrect as a result of incorrect substitution, inconsistent use of signs, the use of $\Delta v = v_i - v_f$, or mathematical errors.

Students had the greatest difficulty showing that the collision was inelastic. Students received marks for demonstrating either algebraically or in words that the collision was not elastic because the kinetic energy before the collision was greater than the kinetic energy after. Students who provided only a verbal explanation needed to indicate where the kinetic energy went in this particular situation (i.e., to heat, crumpling of the bumper, sound). Many student responses indicated that they believe that the difference between an inelastic and an elastic collision is how the objects "bounce" after the collision. Less than 1% of the students did not attempt this question.

For further information, contact Corinne McCabe (cmccabe@edc.gov.ab.ca) at the Student Evaluation Branch at 427-0010. To call toll-free from outside of Edmonton, dial 310-0000.